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Magnet Helium Flow Passage Parameter Summary

Pressure drop for turbulent flow in a non-circular conduit is $? P ? \frac{? v^2}{2}\frac{L}{R_h} f$ where $?$ is average fluid density, v is average fluid velocity, L is conduit length, $R_h$ is channel hydraulic radius, and $f$ is friction factor based on hydraulic radius (which is D/4 for circular pipes).

Substituting $\dot{m} ? ?vA$ where $\dot{m}$ is mass flow and A is conduit cross-sectional area gives $? P ? \frac{\dot{m}^2}{2 ? A^2}\frac{L}{R_h} f$

Substituting the definition for hydraulic radius: $R_h ? \frac{A}{W}$ where W is wetted perimeter, we have $? P ? \frac{\dot{m}^2}{2 ? A^3} WLf$

For turbulent flow, friction factor depends on Reynolds number to the ¼ power and on surface roughness. Neglecting those, one can see that pressure drop per unit length is proportional to $W/A^3$, wetted perimeter divided by flow area cubed.

Thus, for the non-circular flow passages in our magnets, one can compare effective passage sizes by means of the parameter, $W/A^3$.

| **Magnet passage** | Total wetted perimeter (W) (cm) | Total flow area (A) (sq cm) | $W/A^3$ ($cm^{-5}$) | Equivalent tube size (cm dia) | Comments |
|---|---|---|---|---|---|
| TeV dipole single-phase | 112.568 | 17.926 | 0.020 | 3.19 | Total for inner and outer channels |
| TeV dipole two-phase | 45.898 | 12.219 | 0.025 | 3.04 | Annular space |
| Present low beta single-phase | 114.480 | 15.600 | 0.030 | 2.93 | Outer collar channels and yoke holes only |
| Present low beta two-phase | 174.670 | 26.620 | 0.009 | 3.71 | Annular space |
| LHC IR quad coldmass | 62.830 | 78.540 | 0.000 | 8.71 | 4 x 50 mm holes only |
| BTeV IR quad coldmass | 56.000 | 24.000 | 0.004 | 4.37 | Yoke rectangular slots only |

One can see from the equivalent tube sizes that our new low beta cold mass has plenty of single-phase flow area in the present design. If various slots and passages become filled with buswork or instrumentation, we should again check effective flow area.